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Philadelphia Water Supply, Present and Proposed

GEORGE W. FULLER

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With the compliments of the author

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[2] Consulting Engineer, New York, N. Y.

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PHILADELPHIA WATER SUPPLY, PRESENT AND PROPOSED[1]

BY GEORGE W. FULLER[2]

The City of Philadelphia has an unusually interesting water plant. In point of capacity, it is one of the two or three largest plants in the world. For some twenty years it has been producing in the neighborhood of 300,000,000 gallons of water daily. During this interval the population has increased about 40 per cent and water waste has been reduced so as to maintain the supply, although the factor of safety was by no means adequate during much of the period.

In 1899 an investigation was made for betterment of the then unfiltered and highly polluted water supply. A program for filter installation was begun in 1902 and since 1912 all of the water supply has been filtered.

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SOURCE OF SUPPLY

The city derives its water supply from the Schuylkill and Delaware Rivers from intakes located within the city limits. These rivers drain prosperous valleys in which there is much manufacturing, particularly in the case of the Schuylkill River, from which more than 90 per cent of the supply was derived prior to the days of filtration. Intercepting sewers along the margin of the Schuylkill protect the intakes from pollution by city sewage, but, in the valley above, the river is polluted by substantial quantities of city and industrial wastes. The latter contain phenol products and at times the city water is prejudicially affected thereby with the resulting objectionable tastes which are intensified by the application of chlorine, deemed essential for protection against water-borne diseases. The water of the Delaware is not similarly affected by industrial wastes but at the Torresdale intake its quality is affected by the discharge of city sewers, particularly at flood tides which extend to the riffles in the Delaware at Trenton.

REMEDIAL MEASURES

The city is now engaged in building an extensive system of intercepting sewers for delivering the flow of sewers now discharging into the Delaware River and for its treatment. Construction is now underway for a large sedimentation plant for the Northeast district located quite near the approach of the Delaware River Bridge of the Pennsylvania Railroad.

LOCATION OF SUPPLY WORKS

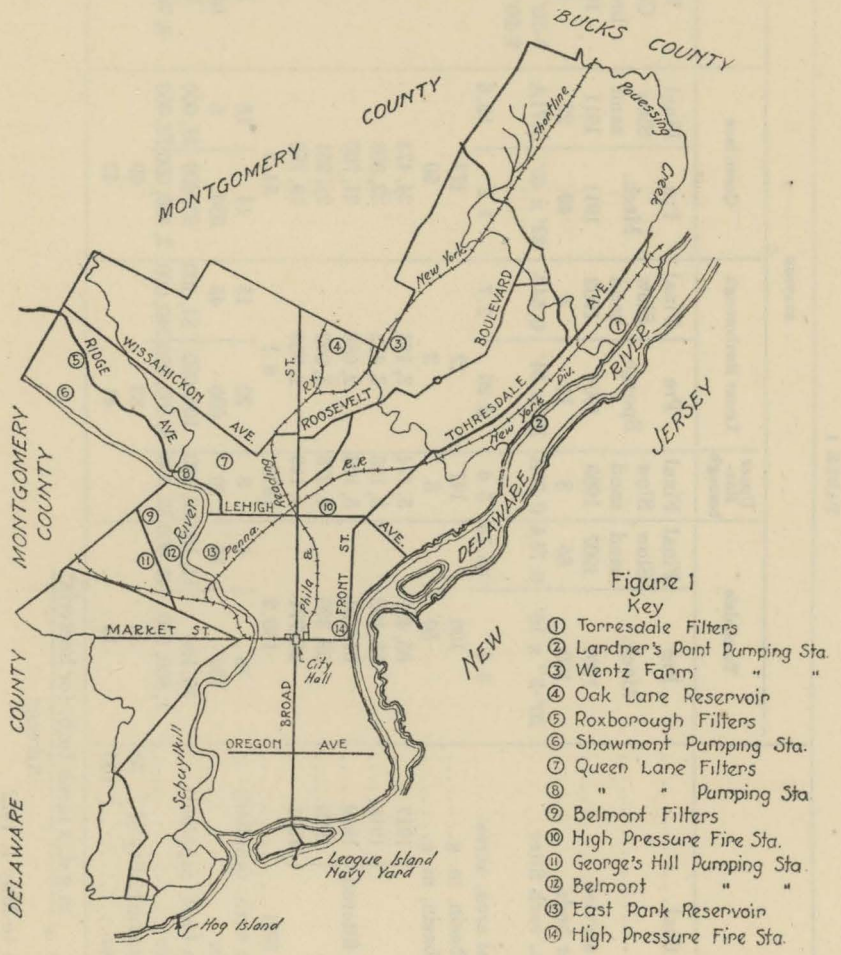
Figure 1 shows a skeleton map of the city with the locations, designated by numbers, of the principal pumping stations, filter, reservoirs and high pressure fire stations.

FILTERS

Table 1 shows type, age, size and basin capacity as well as output of the five filter plants of the city. The Torresdale plant is located adjacent to the Delaware River, while the other four filters were built at or near earlier distributing reservoirs for the Schuylkill supply. Attention is called to the load factors prepared by Mr. Van Loan for the information of his committee of this Association on "Practical Loadings for Purification Processes."

Table 2 summarizes the filter results with respect to turbidity and bacteria, while table 3 summarizes operating costs and alum doses.

The preliminary filters at the Queen Lane plant are being converted into mechanical filters.



TYPHOID STATISTICS

Figure 2 records the typhoid fever death rate in the city during the past thirty-five years with diagrammatic record showing dates when filtered water was progressively delivered to the citizens in

TABLE 1

	STATION								
	Torresdale		Upper Roxborough	Lower Roxborough		Queen lane		Belmont	
Preliminary or final	Pre	Final	Final	Pre	Final	Pre	Final	Pre	Final
Type	Mech.	Slow sand	Slow sand	Sponge	Slow sand	Mech.	Slow sand	Coke breeze	Slow sand
Year placed in service	1909	1907	1903	1904	1902	1911	1911	1909	1904
Number of filter beds	120	65	8	11	5	40	22	18	18
Acreage — Area, each filter	20′–3″ x 16′	0.75A	0.70A	16′ x 64′	0.54A	32′ x 40′	0.71A	9–20′ x 150′ 9–20′ x 90′	0.735A
Acreage — Total area, acres	3.4	48.75	5.6	0.26	2.7	1.2	15.6	1	13.2
Sedimentation basin, m. g.	100		147	12		177		72	
Filtered water basin, m. g.	50		8	3		50		16.5	
Million gallons filtered — 1917	65,497		5,174	3,128		24,473		15,400	
Million gallons filtered — 1918	65,192		5,185	3,612		22,508		16,086	
Million gallons filtered — 1919	67,434		5,106	2,686		21,700		16,597	
Million gallons filtered — 1920	69,350		4,975	3,052		22,251		17,006	
Million gallons filtered — 1921	65,771		5,119	2,966		19,780		15,851	
Daily average, 1921	180.2		14.0	8.1		54.2		43.4	
[1] Load Factors 1921 — Mean turb. (applied)	18	4	8	20	15	14	15	14	8
[1] Load Factors 1921 — Factor	950	15	20	620	45	630	5	610	26
[1] Load Factors 1921 — Mean bact. (applied)	35,100	11,100	12,900	104,000	81,400	52,600	21,000	73,100	41,200
[1] Load Factors 1921 — Factor	1,800,000	41,000	32,000	3,100,000	240,000	2,400,000	73,000	3,200,000	140,000
[2] Number of days turbidity of raw water-over 50	39			83		69		61	
[2] Number of days turbidity of raw water-over 100	15			41		42		40	

[1] Load factor $= \frac{\text{m.g.d. x mean turb. (or bacteria)}}{\text{Acreage}}$

[2] May 1, 1921 to May 1, 1922.

TABLE 2

Filter results

Turbidity in p.p.m.—1921

STATION	RIVER	APPLIED PREFILTERS	REMOVED BY SEDIMENTATION BASIN	APPLIED FINALS	REMOVED BY PRELIMINARY FILTERS BASED ON		FILTERED WATER	REMOVED BY FINALS BASED ON	
					Applied	River		Applied	River
			per cent		*per cent*	*per cent*		*per cent*	*per cent*
Torresdale	23	18	21.7	4	77.8	60.9	0	100	17.4
(Average for past five years)	23	17	26.1	6	64.7	47.8	0	100	26.1
Upper Roxborough	41			8	80.5	80.5	0	100	19.5
Lower Roxborough	41	20	51.2	15	25.0	12.2	0	100	36.6
Queen Lane	40	14	65.0	5	64.3	22.5	0	100	12.5
Belmont	32	14	51.2	8	42.9	12.2	0	100	36.6

Bacteria data—1921

Bacteria per cubic centimeter—gelatin—48 hours, 20°C.

STATION	RIVER	APPLIED PRELIMINARY FILTERS	REMOVED BY SEDIMENTATION BASIN	APPLIED FINAL FILTERS	REMOVED BY PRELIMINARY FILTERS ON APPLIED	FILTERED WATER BASIN	REMOVED BY FINALS AND CHLORINE	TOTAL REMOVED BY PLANT
			per cent		*per cent*		*per cent*	*per cent*
Torresdale	44,300	35,100	20.8	11,100	68.4	4	99.96	99.99
Upper Roxborough	121,000			12,900	89.3	3	99.98	99.998
Lower Roxborough	121,000	104,000	14.0	81,000	22.1	4	99.995	99.997
Queen Lane	72,800	52,600	27.0	21,000	60.1	5	99.98	99.993
Belmont	67,900	73,100	−7.7	41,200	43.6	5	99.99	99.991

Average yearly content of B. coli per 100 cc.

YEAR	RIVER WATER		FINAL EFFLUENT FROM FILTERS				
	Delaware	Schuylkill	Torresdale	Queen Lane	Belmont	Roxborough	
						Lower	Upper
1918	670[1]	880[1]	0.70[2]	1.8[2]	2.6[2]	2.0[2]	1.4[2]
1919	590	940	0.60	3.43	2.46	2.55	2.47
1920	790	980	1.2	4.4	3.8	3.8	3.6
1921	990	980	2.1	2.3	2.0	2.1	2.0

[1] Based on 0.1 cc. tests.

[2] Based on 10 cc. tests.

proportions depending upon the completion of the respective filter plants above described.

DISTRIBUTING RESERVOIRS

When the filter plants were built there were also installed covered distribution reservoirs for the filtered water adjacent to each of the filter plants, five in number, as shown in table 4. The Oak Lane

TABLE 3

Filter statistics

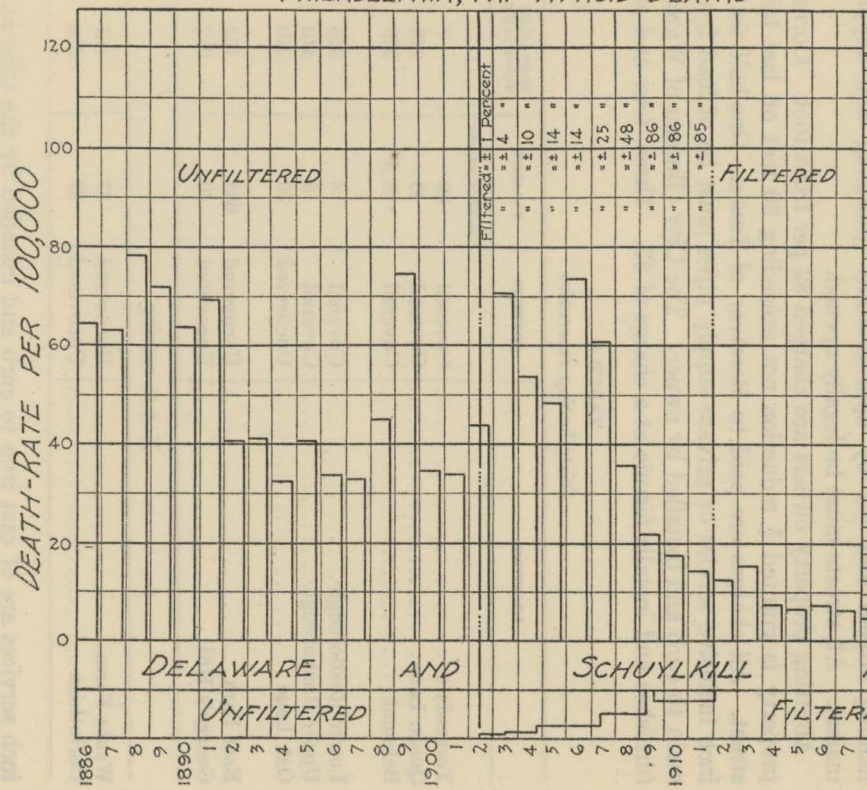
Operating cost for 1921

	BELMONT		QUEEN LANE		ROXBOROUGHS		TORRESDALE	
	1920	1921	1920	1921	1920	1921	1920	1921
Pre filters (dollars)	35,947	38,827	33,489	40,681	11,276	6,415	46,086	66,140
Final filter (dollars)	61,207	78,830	58,261	61.019	41,713	48,719	117,555	154,326
Total cost (dollars)	97,154	117,656	91,750	101,700	52,989	55,134	163,641	220,466
Million gallons filtered	17,006	15,854	22,251	19,947	8,027	8,086	67,434	65,768
Cost per million gallons (dollars)	5.71	7.42	4.12	5.09	6.60	6.82	2.42	3.34

Alum application

	DELAWARE RIVER—TORRESDALE			SCHUYLKILL RIVER—QUEEN LANE		
	Treated	Average actual dosage	Average for year	Treated	Average actual dosage	Average for year
	per cent	*grains*	*gallons*	*per cent*	*grains*	*gallons*
1917				9.3	2.00	0.19
1918	4.5	1.54	0.07	6.0	1.49	0.09
1919	3.5	1.55	0.05	4.3	2.10	0.09
1920	4.6	1.64	0.08	5.8	1.75	0.10
1921	5.8	1.69	0.10	7.5	2.2	0.15

reservoir for the storage of filtered water from the Torresdale plant was also built. This reservoir was provided with footing courses for piers but covers were not built. Prior to filtration there were four uncovered distributing reservoirs, all at comparatively low elevation and of which two have been out of service for some time. The East Park reservoir is held for emergency use chiefly.



Year	Population 100,000	Deaths	Deaths per 100,000
1886	9619	618	64.2
7	9.825	621	63.2
8	10.036	785	78.2
9	10.250	736	71.8
1890	10.470	666	63.6
1	10.694	683	63.9
2	10.922	440	40.3
3	11.156	456	40.9
4	11.394	370	32.5
5	11.638	469	40.3
6	11.887	402	33.8
7	12.141	401	33.0
8	12.400	566	45.6
9	12.666	948	74.9
1900	12.937	449	34.7
1	13.172	444	33.7
2	13.412	588	43.8
3	13.655	957	70.1
4	13.903	744	53.5
5	14.157	684	48.3
6	14.413	1063	73.8
7	14.675	890	60.7
8	14.942	533	35.7
9	15.214	331	21.8
1910	15.490	270	17.4
1	15.745	223	14.2
2	16.000	203	12.7
3	16.266	255	15.7
4	16.533	124	7.5
5	16.805	109	6.5
6	17.081	128	7.5
7	17.362	111	6.4
8	17.647	85	4.8
9	17.937	80	4.5
1920	18.232	62	3.4
1	18.530	42	2.3
2	18.830	52	2.8
3			
4			
5			
6			

STEAM PUMPING EQUIPMENT

The city has recently installed a number of new pumping units as shown by slides not here reproduced. Table 5 contains a description of and summary of coal consumption at the main pumping stations.

DISTRIBUTION PIPE SYSTEM

All pipe is laid by authority of Council by (*a*) special ordinance—naming streets and (*b*) by appropriation (pumping and supply mains). All streets must be legally opened.

Abutting property owners are charged $2 per front foot. Corner property is granted $\frac{1}{3}$ reduction not exceeding 50 feet on last laid street. All charges are paid to Receiver of Taxes. One-half to 2 inch inclusive service or private supply pipes must be of lead from main to curb and installed by owner. The City (Bureau of Water) furnishes and installs ferrule at a charge of $2. Three, four and six

TABLE 4

Distributing reservoirs

LOCATION	COVERED	CAPACITY	ELEVATION FLOW LINE
		million gallons	
Torresdale	Covered	50	7
Queen Lane	Covered	40	216
Belmont	Covered	16.5*	239
Lower Roxborough	Covered	3	326
Upper Roxborough	Covered	8	410
Oak Lane	Uncovered	70	210
East Park	Uncovered	688	133
George's Hill	Uncovered	40	212
Not in service			
Wentz Farm	Uncovered	37	167
Corinthian	Uncovered	37	120

inch services are of cast iron to curb and installed by the City at a charge of $50, $60 and $75 respectively. A permit to open the street must be secured by the owner from the Bureau of Highways at a charge of $20 for paved streets and a nominal charge for unpaved streets.

HIGH PRESSURE FIRE SYSTEM

The system has two high pressure fire systems of which the Race Street Station on the Delaware River was installed about twenty years ago. There is also a newer plant about ten years old taking filtered water and located some distance north from the central part of the City. The main features of these systems which were installed on account of the relatively low pressure of the city supplv and in a congested part of the city are shown in table 6.

FIRE PROTECTION RATING

During 1922 a survey and report was made by the National Board of Fire Underwriters of the more important features as shown in the following summary:

1. Out of a possible total of 1700 points of demerit in grading, the entire water supply was given a deficiency of 84 points.
2. Outside of the zone protected by the High Pressure Fire System, the demerits totaled 391.
3. In the zone protected by the High Pressure Fire System, the demerits totaled 30.
4. Allotting proper weight to these respective districts, the water supply for the City as a whole was penalized 84 points.
5. The principal factors entering into the 391 points of demerit are as follows:

a. Fire hydrant pressure lower than 75 pounds over a considerable territory, 48 points.

b. Fairmount Dam, a wooden structure which the Board of Consulting Engineers recommends replacing with a permanent masonry dam, 36 points.

c. Three (3) large and important supply mains laid side by side in the same street, 18 points.

d. Deficiency in fireproof construction at Pumping Stations, 21 points.

e. Gridiron system not exceeding 6-inch and 8-inch pipes, in built-up sections, 149 points.

f. Dead ends, 15 points.

g. Old type gate valves, 15 points.

h. Old type fire hydrants, 12 points.

The general system of grading followed in this survey is described in the Journal of this Association of January, 1922, by Robert E. Andrews, Assistant Chief Engineer, National Board of Fire Underwriters, San Francisco. Quoting from that paper:

TABLE 5

Pumping machinery—Steam

Bureau of Water, Philadelphia; at beginning of 1922

STATION	DESCRIPTION					WORKING CONDITIONS			
	Number of units	Year installed	Builder	Type		Rated capacity m.g. per 24 hours	Steam pressure per sq. inch	Vacuum in mercury	Total head
				Steam end	Water end				
							lbs.	*inches*	*feet*
Belmont	2	1916	De Laval	Turbine	Centrifugal	22	190	28	316
	2	1908	Bethlehem	Hor. cross comp.	Double plunger	10	150	26	316
	1	1900	Holly	Hor. comp.	2 Plunger	10	150	27	316
	1	1895	Worthington	Duplex comp.	2 Plunger	20	100	24	316
Queen Lane	1	1917	De Laval	Turbine	Centrifugal	25	175	28	271
	2	1921	De Laval	Turbine	Centrifugal	40	175	28	271
Shawmont	1	1887	Gaskill	Hor. comp.	2 Plunger	10	100	24	400
	2	1908	Snow	Hor. cross comp.	2 Plunger	5	150	26	400
	1	1916	Southwark	Turbine	Worth-Cent.	10	150	28	400
	1	1917	Southwark	Turbine	Worth-Cent.	10	150	28	400
	1	1918	Southwark	Turbine	Worth-Cent.	10	150	28	400
Ld's Pt. 2....	6	1903	Holly	Vert. trip. exp.	3 Plunger	20	150	28	184
Ld's Pt. 3....	4	1908	Holly	Vert. trip. exp.	3 Plunger	20	175	28	253
Ld's Pt. 3....	2	1909	Holly	Vert. trip. exp.	3 Plunger	30	175	28	184
Ld's Pt. 4....	1	1918	De Laval	Turbine	Centrifugal	35	175	29	184
Torresdale	6	1907	Ames Engines R. D. Wood Pumps	Vert. uniflow	Centrifugal	40	175	26	42
	1	1908	Bates Engine Allis Chalmers pump	Vert. cross comp.	Centrifugal	40	175	26	42
	1	1910	De Laval	Turbines	Centrifugal	50	175	26	42

1921 annual operating data

STATION	PUMPAGE M.G.	MEAN HEAD (FEET)	COAL (TONS)	MILLION FT. LBS. PER 100 LB. COAL	COST PER M.G. 100 FT.
Belmont	17,596	296	34,809	60.8	5.67
Queen Lane	21,322	271	36,218	57.4	5.27
Shawmont	8,896	393	24,550	54.4	9.48
Ld's Pt	64,595	202	84,615	63.7	6.37
Torresdale	69,204	43	43,088	29.2	13.41

Approximate b.t.u. per lb. coal—12,000.

TABLE 6

High pressure fire system

STATION		RACE ST.	FAIRHILL
WATER SUPPLY		Delaware river	5 m.g. basin (filtered water)
Length of mains	20 inches	1.0–mile	7.5–miles
	16 inches	1.2–miles	5.5–miles
	12 inches	5.5–miles	10.5–miles
	8 inches	8.0–miles	8.5–miles
	Total	15.7–miles	32.0–miles
Power	Gas engines—300 h.p.	7	10
	(3 cyl. vertical)—125 h.p.	2	1
Pumps triplex-double acting	Speed-r.p.m.	40	40
	No. 1200 g.p.m.	7	10
	No. 350 g.p.m.	2	1
	Total capacity-station-g.p.m.	9100	12, 350
No. of hydrants		289	600
Normal pressure when not in service		15 to 45 lbs.	10 to 45 lbs.
Pressure of fire service		175 to 300 lbs. as ordered	

	1921	1920	1921	1920
Services	39	35	8	15
No. of service calls	209	166	268	270
Total	248	201	276	285

Total-both stations	1920—486 1921—524	
Cost: Ground	$130, 000	Old resevoir site
Building	90, 000	$150, 000
Engines and pumps	180, 000	250, 000
Mains	480, 000	1, 750, 000
Total	880, 000	2, 150, 000
Total-both stations	$3, 030, 000	
Cost of operating, year 1921: Labor	$81, 011.38	
Other cost	8, 879.04	
Total	$89, 890.42	

The plan adopted is like that of marking a school-boy's examination paper, where so much is taken off for every mistake. The sum of the maximum points of deficiency totals 5000 and is divided in accordance with the relative values of the features as follows:

	MAXIMUM POINTS	PHILADELPHIA SURVEY
Water Supply	1700	84
Fire department	1500	227
Fire alarm	550	171
Police	50	
Building laws	200	28
Hazards	300	64
Structural conditions	700	
Total	5000	

FINANCIAL DATA

In table 7 is given a summary of recent revenue statements of the City Water Bureau together with minimum meter rates and the quantities of water allowed therefor. Attention is called in this connection to the fact that the distribution pipe system is paid for largely by assessment and also to the fact that all water passed through a meter in excess of the minimum quantity allowed for each size and connection is charged at a uniform rate.

NEW SOURCES OF SUPPLY

In 1920, an investigation was made of extensions and improvements of the present city water works system by a Board of Consulting Engineers, consisting of J. W. Ledoux, Chairman, George W. Fuller, Joseph F. Hasskarl, J. Waldo Smith. Figure 3 shows the location of various watersheds considered by this Board, which reported conclusions and recommendations as follows:

1. The present sources of supply at local points on the Delaware and Schuylkill Rivers must of necessity be continued for a time and, barring occasional tastes due to industrial drainage, can be made to furnish a safe and adequate supply.

2. Extensive improvements and additions must be made to the present works at once in order to insure an ample quantity at a reasonable pressure and of a satisfactory quality throughout the entire City. This requires extensive changes in and additions to

TABLE 7

Financial statement

	1921	1920	1919
Total revenue	$6,222,872.06	$6,523,240.36	$6,209,678.00
Per inhabitant	3.33	3.55	3.43
Per mile of pipe	3,219	3,414	3,274
Per 1,000 gallons	$0.057	$0.056	$0.055
Per cent sales from:			
Metered services	45.4	48.1	44.0
Unmetered services	54.6	51.9	56.0
Revenue from:			
City departments	0	0	0
Fire protection	0	0	0
Discount to charities	Averages 90 per cent—equivalent to about $130,000 annually		
Services	Total 388,000; metered 88,000; per cent metered, 23		
Total operating expense: inc. high pressure fire	$3,711,584.06	$3,766,059.73	$3,210,799.16

Minimum meter rates and quantities of water allowed therefor

	minimum	*cubic feet*
For ½ inch ferrule	$8.00	8,000
For ⅝ inch ferrule	12.00	12,000
For ¾ inch ferrule	18.00	18,000
For 1 inch ferrule	32.00	32,000
For 1¼ inch ferrule	50.00	50,000
For 1½ inch ferrule	75.00	75,000
For 2 inch ferrule	130.00	130,000
For 3 inch ferrule	290.00	290,000
For 4 inch ferrule	515.00	515,000
For 6 inches ferrule	1,150.00	1,150,000

All water in excess in any year of the quantity hereinabove fixed for any metered connection shall be charged for at the rate of forty (40) cents per one thousand (1000) cubic feet.

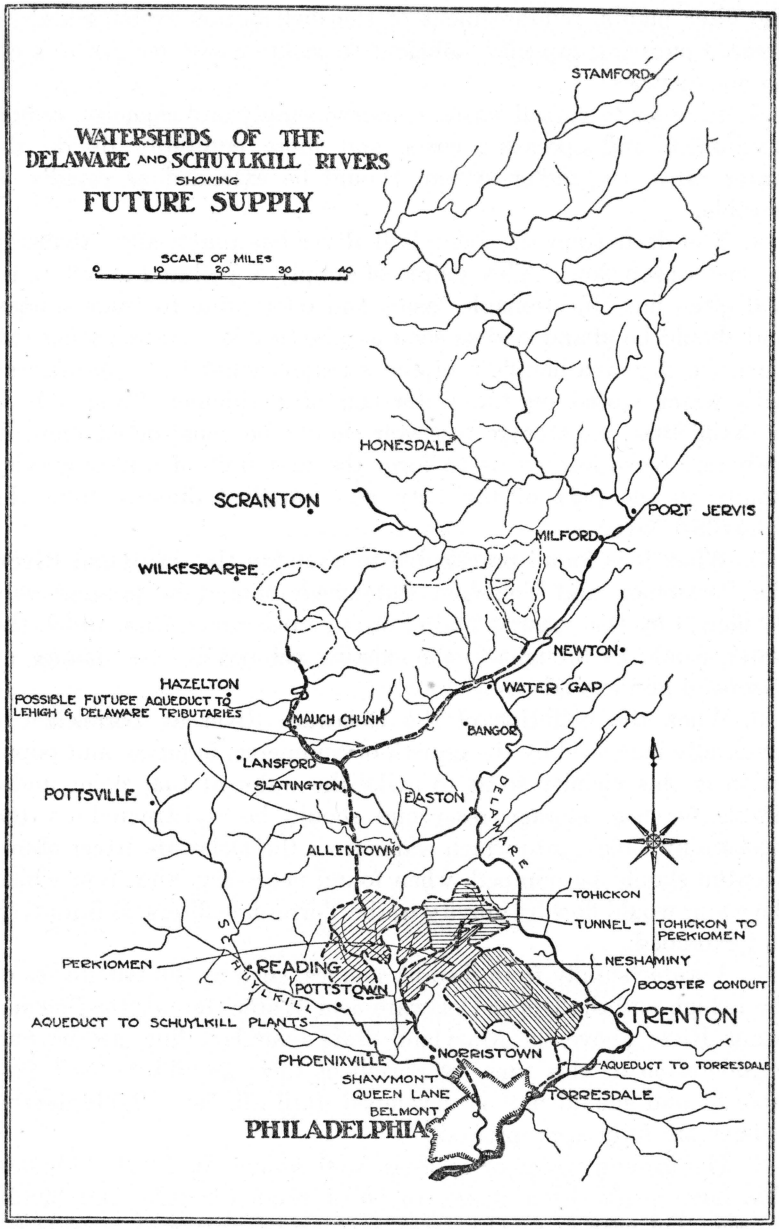

WATERSHEDS OF THE
DELAWARE AND SCHUYLKILL RIVERS
SHOWING
FUTURE SUPPLY
SCALE OF MILES
0 10 20 30 40
STAMFORD
HONESDALE
SCRANTON
PORT JERVIS
MILFORD
WILKESBARRE
NEWTON
HAZELTON
POSSIBLE FUTURE AQUEDUCT TO LEHIGH & DELAWARE TRIBUTARIES
WATER GAP
MAUCH CHUNK
BANGOR
LANSFORD
SLATINGTON
POTTSVILLE
EASTON
DELAWARE
ALLENTOWN
TOHICKON
TUNNEL — TOHICKON TO PERKIOMEN
SCHUYLKILL
PERKIOMEN
READING
NESHAMINY
POTTSTOWN
BOOSTER CONDUIT
TRENTON
AQUEDUCT TO SCHUYLKILL PLANTS
NORRISTOWN
PHOENIXVILLE
AQUEDUCT TO TORRESDALE
SHAWMONT
QUEEN LANE
TORRESDALE
BELMONT
PHILADELPHIA

FIG. 3.

the filter plants, reinforcement of the distribution systems and increased pumping capacity sufficient to secure a safe reserve to meet all emergencies.

3. In order to curtail waste, conserve supply and capacity, reduce investment and operating costs, and more equitably divide the water rates, the meter system should be extended as rapidly as feasible.

4. The draft from the Schuylkill River has practically exhausted its low season flow. This source of supply is polluted at all times and often has objectionable tastes and odors, due to trade wastes, and should be abandoned as soon as practicable. Anticipating this time the dry weather flow of the stream should be supplemented with water stored on the watershed of Perkiomen Creek. It is essential that one storage reservoir should be constructed immediately and be so located as to form the first unit of a semi-gravity supply to the part of the City now supplied directly from the Schuylkill River.

5. When it is found practicable to abandon the Schuylkill River, the Perkiomen and Tohickon watersheds should be progressively developed by the construction of storage reservoirs, from which the water should be brought to the existing Schuylkill River plants, as improved and extended.

6. When the pollution of the Delaware River at Torresdale is materially increased by the growth of commerce, industry and population in this vicinity so as to make the water at that point undesirable for use, storage reservoirs should be constructed on the Neshaminy Creek, into which water from the Delaware River above Trenton should be pumped, when found necessary, and from which the water would flow by gravity to the Torresdale filters, as improved and extended.

7. A water supply from distant sources, such as the tributaries of the Lehigh and the Upper Delaware near Water Gap, or the Susquehanna River above the Maryland State boundary line, are beyond consideration at this time by reason of their prohibitive cost (see table 8) and should not be developed until all the suitable nearby sources are fully appropriated.

8. The ground water or artesian well sources in South Philadelphia have so far been shown to be of small quantity and highly impregnated with mineral matter, making the water unsuitable for domestic or industrial purposes. However, contracts for test wells

are about to be let and final conclusions and recommendations need not be made until additional information and data have thus been obtained. Should adequate and satisfactory water-bearing strata be found in the lower part of the City, a supply could be developed as a separate unit which could be readily connected with the distribution system when and as desired.

TABLE 8

Comparative 1920 estimates of costs of projects

PROJECT*	COST OF STORAGE RESERVOIRS AND HEAD WORKS	COST OF AQUEDUCTS	COST OF FILTRATION PLANT AND CHANGES OF DISTRIBUTION SYSTEM	TOTAL COST	CONSTRUCTION COST PER MILLION GALLONS DAILY SUPPLY
1. Perkiomen.....	$ 56,073,000	$50,819,000	$28,000,000	$134,900,000	$270,000
2. Upper Lehigh..	102,635,000	176,776,000	45,000,000	324,411,000	649,000
3. Susquehanna...	19,584,000	207,703,000	28,000,000	255,287,000	511,000

* Project 1. Perkiomen, Tohickon, Neshaminy, supplemented by the Delaware River above Trenton; semi-gravity supply; recommended project.

Project 2. Tributaries of the Upper Lehigh and of the Delaware River near the Water Gap; gravity supply to reconstructed plants in the city.

Project 3. Susquehanna River above the Maryland State Line; gravity flow to existing pumping stations on the Schuylkill and to the Torresdale Filtration Plant (Elevation 35).

This recommended program in 1920 called for an expenditure of some thirty-five million dollars, at prices then prevailing, in the course of the next six or eight years and summarized in the report of the Board as follows:

First: For the construction of the first impounding reservoir on the Perkiomen Creek with necessary development of program for stored water supply $8,000,000.

Second: For improvements in and extensions to the Delaware River supply works, $6,000,000.

Third: For improvements in and extensions to the Schuylkill River supply works, $4,000,000.

Fourth: For extension of distribution mains and construction of distributing reservoir for the northeast portion of the City, $8,000,000.

Fifth: For extensions and betterments to existing distribution reservoirs and main pipe lines, $5,000,000.

Sixth: For general improvements essential for safe maintenance of plant, $4,000,000.

It will be noted that only the first item pertains to the development of a new stored water supply while the other items relate to extensions and betterments to the existing works within the City. It was estimated that during the next fifty years they will care for a population of about 3,250,000 people, which, with complete metering of all services, may allow the average consumption to be kept at 150 gallons per capita daily or an average supply of 500 million gallons daily, requiring works for limited periods capable of supplying 600 million gallons of water daily. It was estimated that the recommended project from nearby tributaries as described and supplemented by Delaware River water above Trenton would call for investments at 1920 prices as follows: Cost of storage reservoirs and head works, $56,073,000; cost of aqueducts, $50,819,000; cost of filtration plant and changes of distribution system, $28,000,000; total cost $134,900,000.

Some six million dollars have been spent during the last two or three years in revamping and enlarging the existing supply works in order to make them safe during the period required for the construction of the new supply works. This recent work is related to pumping, filtering and feeder main facilities as well as overcoming the abnormally deferred maintenance which accumulated during the war period at Philadelphia, as was generally the case with all public service enterprises.

In closing this paper, the writer desires to express his appreciation to Chief Davis and his staff for furnishing up-to-date information for record of interest to the members of this Association concerning the works of the Philadelphia Bureau of Water, the personnel of which is as follows:

CITY OF PHILADELPHIA

DEPARTMENT OF PUBLIC WORKS

FRANK H. CAVEN, *Director*

Bureau of Water

CARLETON E. DAVIS, *Chief*
Construction, John S. Ely
Mechanical Design, Harrison R. Cady
Pumping Stations, S. H. Thompson
Distribution, Daniel A. McCrudden
Filtration, Albert Tolson
Sanitary Control, Lyle L. Jenne

S. M. VAN LOAN, *Deputy Chief*
Laboratory, Dr. George E. Thomas
Accounting, Carl H. Stanger
Chief Clerk, Neill Crowley
Revenue, John J. Gaffney
Executive, Wm. W. Whitby
High Pressure, A. J. Donnelly